6.1.1 Normally regulations require final plume rise to be used at all downwind receptors. However, because of the complex terrain surrounding the site, the NYDEC has recommended using transitional plume rise.[3]

6.1.2 Stack-tip downwash effects are included.

6.1.3 Buoyancy induced dispersion effects are parameterized.

6.1.4 Default wind profile coefficients are assigned (0.07, 0.07, 0.10, 0.15, 0.35, 0.55 for the rural mode; and 0.15, 0.15, 0.20, 0.25, 0.30, 0.30 for the urban mode).

6.1.5 Default vertical potential temperature gradients are assigned (A:0, B:0, C:0, D:0, E:0.02, F:0.035 K/m).

6.1.6 A decay half-life of 4 hours is assigned if SO_2 is modeled in urban mode; otherwise, no decay is assigned.

6.1.7 Direction specific building downwash and adjustments to plume rise and plume height are used when the physical stack height is less than HB+0.5L, where HB is the height of the building adjacent to the stack and L is the lesser of the building height and maximum width.

6.2 COMPLEX I Input Parameters

Guidelines on Air Quality Models recommends the use of certain settings when using COMPLEX I in the screening mode. The following settings will be used in all the COMPLEX I runs:

6.2.1 Terrain adjustment is used in the model.

6.2.2 Buoyancy induced dispersion effects are used.

6.2.3 Wind profile coefficients for the rural mode will be used (0.07, 0.07, 0.10, 0.15, 0.35, 0.55).

6.2.4 An anemometer height of ten (10) meters will be used.

6.2.5 The terrain adjustment values will be set to 0.5, 0.5, 0.5, 0.5, 0.0, and 0.0 for each stability class, A through F respectively.

6.2.6 The distance limit for plume centerline from ground (ZMIN) will be set to 10.

6.2.7 The "Valley Equivalent" option of COMPLEX I uses worst case meteorological data. For rural areas, the assumptions used are: (1) Pasquill-Gifford Stability "F"; (2) wind speed of 2.5 m/sec; (3) mixing height of 9999 meters; (4) six (6) hours of occurrence.

6.2.8 The ambient temperature will be set to 298 K.

6.2.9 The wind directions used will correspond to the receptor grid azimuths. The wind directions will range from 0° to 350° in 10° increments.

6.2.10 A conversion factor of 4 will be used to convert the 24-hour averages to 1-hour averages. A conversion factor of 0.1 will be used to convert the 1-hour averages to annual averages.[4]

7. Stack Parameters

7.1 Location

The coordinates of the stack are as follows:

Latitude	41.313 degrees
Longitude	74.140 degrees
UTM coordinates	
Northing	4573731 meters
Easting	572000 meters
Zone	18

7.2 Elevation

The elevation at the stack base is 531.5 feet (162 meters) above mean sea level.

7.3 Height

The stack height from ground level is presently seventy (70) feet (21.3 meters). The modeling will be used to determine a more acceptable stack height to meet regulations. The dispersion models will be run at different stack heights until a height is found which will meet all Tier III requirements. The stack height will then be increased to this new height with NYDEC approval.

7.4 Diameter

The inside diameter of the stack is five (5) feet (1.52 meters).

7.5 Flow Rate

The maximum stack flow rate is 58076 ACFM (1645 m^3/min).

7.6 Exit Temperature

The flue gases are cooled in a waste heat boiler to approximately 625°F (330°C) before exiting the system through the stack.

7.7 Exit Velocity

The exit velocity of the flue gas was calculated to be 49.30 feet per second (15.03 meters per second) at the above conditions.

7.8 Emission Rate

A standard rate of one (1) gram per second will be used in the dispersion models to determine a dispersion coefficient for the stack.

7.9 Adjacent Building

The controlling building's dimensions will be used in the ISCST model to determine the effects of building downwash. The building height and projected width are 60.8 feet (18.53 meters) and 268.0 feet (81.69 meters) respectively. (See Section 5 for the controlling building and GEP stack height determination.)

8. Land Use

The Simplified Land Use Process found in Guidance on Metals and Hydrogen Chloride Controls for Hazardous Waste Incinerators was used to determine the classification of the land within a three kilometer radius of the site. The process uses the color coding on USGS maps to determine land use. The process is based on the assumption that most areas will have clear cut urban/rural classifications which can easily be determined by review of a USGS map. The typing designations used for the color codes on a topographical map are as follows:

Green Wooded areas. Designated as rural.

White Areas which are not wooded and do not have densely packed structures. Industrial areas, parks, and undeveloped rural land will appear as white on topographical maps. Only the industrial areas are considered urban. White areas are designated as rural unless the areas appear to be industrial. Industrial areas can be identified by map symbols, such as large buildings or railroad tracks.

Pink Pink areas indicate house omission and are designated as urban.

Blue Water area. Designated as rural.

Purple Purple areas indicate revisions to previous maps. If individual residences are shown on the map, the area is considered rural; otherwise, the area is designated as urban.

A three kilometer radius area is reviewed using the above color codes. If less than thirty (30) percent of the area is labeled as urban using visual inspection of the codes above, the land is considered rural. If the percentage of urban area is greater than fifty (50) percent, the area is considered urban. If the urban area is between thirty (30) and fifty (50) percent, a more detailed review using either a planimeter or the Auer land use method is required.

Table 11 gives the percentage of land in the area which is classified under each of the above land use categories. Based on a visual inspection of the USGS map, the area surrounding the site is considered rural (See Attachment 1). Therefore, rural coefficients will be used in the dispersion modeling.

Table 11

Color Coding of Land Use Types

Color Coding	Percentage of Total Area
White (Industrial)	11%
White (Rural)	20%
Green	69%
Blue	1%
Pink	0%
Purple (Urban)	0%
Purple (Rural)	0%
Rural	89%
Urban	11%

9. Terrain Analysis

Receptor elevations were determined using a USGS topographical map (See Attachment 1). The elevations will be included in the modeling. The maximum terrain rises are given in Table 12.

Table 12

Terrain Elevations

Maximum Radius (meters)	Terrain Rise (feet AMSL)
0 - 200	540
200 - 500	600
500 - 1,000	680
1,000 - 1,500	780
1,500 - 2,000	1000
2,000 - 3,000	1340
3,000 - 4,000	1280
4,000 - 5,000	1340

The elevation at the base of the stack is 531.5 feet. Presently the elevation at the top of the stack is 601.5 feet. This elevation will be changed based on the modeling results. The terrain rises above the stack within the first kilometer.

10. Receptor Grid

The receptor grid will extend out to a five (5) kilometer radius. The shortest distance from the stack to the property fence line is approximately 160 feet (48.8 meters). The minimum distance between source and receptor allowed with ISCST is $3 \times HB$, where HB is the height of the building. Using the controlling building's dimensions, this value is 182.4 feet (54.7 meters). This distance will be used as the first receptor grid ring for both the ISCST model and the COMPLEX I model. Both the ISCST and the COMPLEX I models will be run using sector widths of 10°. Table 13 gives the ring distances that will be used in the two models. If the maximum impact should occur beyond 2000 meters, a second analysis will be performed using a 100 meter spaced grid around the location of the maximum impact.

Table 13

Polar Receptor Grid Range for ISCLT

Ring	Ring distance (m)
1	55
2	100
3	200
4	300
5	400
6	500
7	600
8	700
9	800
10	900
11	1000
12	1100
13	1200
14	1300
15	1400
16	1500
17	1600
18	1700
19	1800
20	1900
21	2000
22	2250
23	2500
24	2750
25	3000
26	3250
27	3500
28	3750
29	4000
30	4250
31	4500
32	4750
33	5000

11. Discrete Receptors

To determine the impact of the stack emissions on the neighboring area, discrete receptor points will be modeled in the analysis. These receptors include nearby homes, schools, churches, other large buildings, parks, campgrounds, golf courses, and lakes.

There are many small residential areas surrounding the NEPERA facility. In order to model the impact at nearby homes, some assumptions must be made. It would be impossible to model the effects of the stack on every home in the area. Therefore, the USGS topographical map (Attachment 1) was reviewed to determine the locations of nearby homes. A receptor grid similar to that described in Section 10 will be used to approximate these locations. To better approximate the locations of homes, the receptor grid will use sector widths of 5°. Within a two kilometer radius, each receptor point which corresponds to the location of a home shown on the USGS map will be modeled at both ground level and a height of 24 feet (to approximate a two story home). Table 14 gives the receptor points that will be modeled as homes. If the maximum concentration occurs outside the two kilometer radius, this same procedure will be used to model the impacts to homes in the area of the maximum concentration.

The location, height, and ground level elevation for the other discrete receptor points that will be modeled are given in Table 15. The receptor locations were taken from the USGS map. The heights of the buildings were determined by visual inspection. The receptors will be modeled at ground level and at the height of the highest air intake. For most of the buildings, this height was assumed to be roof height.

Table 14

Locations of Nearby Homes

	Range (m)	Azimuth (degrees)
5	200	210, 260, 270, 275, 280
10	300	210, 250, 255, 260, 265, 270, 275, 280, 285, 290
14	400	245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295, 305, 315, 320
20	500	20, 25, 205, 210, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 310
19	600	35, 205, 210, 220, 225, 230, 235, 240, 245, 250, 255, 260, 265, 270, 275, 280, 285, 290, 295
19	700	35, 185, 195, 200, 205, 215, 220, 225, 230, 235, 245, 260, 265, 270, 275, 280, 285, 290, 350
9	800	185, 215, 240, 245, 255, 260, 265, 280, 285
7	900	230, 240, 245, 250, 255, 260, 265
10	1000	185, 225, 235, 245, 250, 255, 260, 290, 295, 320
13	1100	10, 15, 45, 240, 245, 260, 265, 275, 280, 285, 290, 320, 325
7	1200	5, 10, 240, 245, 260, 265, 285
8	1300	0, 5, 245, 275, 285, 290, 295, 355
7	1400	105, 185, 245, 270, 275, 280, 295
7	1500	225, 230, 250, 255, 265, 270, 275
6	1600	10, 230, 250, 270, 275, 340
6	1700	225, 250, 275, 280, 285, 340
6	1800	10, 35, 115, 220, 225, 275
11	1900	15, 35, 40, 45, 50, 165, 225, 250, 275, 280, 335
12	2000	25, 35, 40, 45, 50, 205, 210, 215, 245, 280, 290, 295

Table 15

Discrete Receptors

Receptor	Range (km)	Azimuth (degrees)	Elevation (ft AMSL)	Height (ft)
Thevenet Hall	4.00	0	840	36
Sewer Plant - POTW	0.50	30	560	24
18 Monroe-Woodbury Central H.S.	1.50	40	620	24
Monroe-Woodbury Jr. H.S.	1.50	20	660	24
Commercial Warehouse (IBM)	2.50	50	500	24
Office Plant	2.75	50	500	24
Education Center	3.25	35	520	36
Columbia Univ. Arden House	2.50	120	1300	48
Sapphire Elementary School	2.50	240	900	36
St Patricks Villa	2.75	235	900	24
Harriman Heights School	3.25	240	880	36
St. Patricks Church	0.75	275	600	24
Pine Tree School	2.75	270	760	24
Shopping Mall	3.00	290	614	24
Monroe Bowl-O. Fun	5.00	300	640	24
No. Main St. School	4.50	310	680	24
Monroe Temple	4.75	310	640	24
Jehovah Witness Assembly Hall	5.00	330	800	24
Park to North	0.50	0	540	
Monroe-Woodbury Playground	1.50	30	620	
Central Valley Golf Course	4.50	45	640	
West Point Girls Camp	5.00	45	700	
Camp Wildwood	3.00	50	500	
Harriman State Park	1.50	100	600	
26 Monroe Golf Course	3.25	285	620	
Peckmans Pond	2.00	70	493	
Summit Lake	4.00	90	1067	
Upper Twin Lake	5.00	90	838	
Forest Lake	3.50	110	1050	
Cranberry Lake	3.00	130	1015	
Lake Cohasset	4.25	150	863	
Upper Lake Cohasset	4.50	150	901	
Echo Lake	4.00	170	709	
Lake Sapphire	2.50	210	880	
Shadowmere Lake	2.75	220	870	
Blendale Lake	2.50	225	820	
Blythea Lake	2.75	225	870	
Lake Winape	5.00	240	819	
Monroe Ponds	4.50	300	620	
Mountain Lakes	2.25	310	580	
Forest Road Lake	4.00	325	640	
Coronet Lake	4.00	340	720	
Cromwell Lake	3.50	350	840	
Saltzman Lake	4.50	10	780	

12. Weather Station

12.1 Surface Data

Surface weather stations in the area of Harriman, New York, were investigated to determine which would be the most representative of the site. The weather stations in the area are listed in Table 16.

Table 16

Surface Weather Stations

Station Name	Latitude	Longitude	Distance From Site (km)
Newburgh/Stewart NY	N 41° 30'	W 74° 6'	30.5
Teterboro NJ	N 40° 51'	W 74° 3'	47.5
White Plains NY	N 41° 4'	W 73° 43'	49.1
Poughkeepsie NY	N 41° 38'	W 73° 53'	52.5
LaGuardia NY	N 40° 46'	W 73° 54'	61.2

The proper surface data station to be used was discussed with the NYDEC. The Newburgh/Stewart Station appears to be the most representative of the site. The terrain is very similar in this area to the terrain near Harriman. It is also the closest station to the site. The most recent data available for the Newburgh/Stewart station is from 1965 through 1969. This data was examined by the NYDEC for completeness. The data was determined to be complete and the NYDEC has agreed to supply the data for the modeling.

12.2 Upper Air Data

Upper air data is not as location dependent as surface data. Upper air stations are representative of a large area. There are three upper air stations available near Harriman, New York. These are: Atlantic City, New Jersey, Albany, New York, and Buffalo, New York. The Albany upper air station will be used with the Stewart surface data in the dispersion modeling. This data is also being supplied by the NYDEC.

13. Cumulative Toxic Impacts

Impacts from other sources both on-site and off-site were investigated to determine cumulative toxic impacts on the area. There are six other stacks located on the NEPERA Harriman facility. These can be seen in the plot plan given as Attachment 5. The six additional stacks are involved with the following processes:

- Two gas fired burners which are used to provide heat to certain NEPERA processes.
- One gas fired boiler.
- Two dual-fuel fired boilers which are run on natural gas. The boilers are run on fuel oil only when the supply of natural gas is limited.
- One fume incinerator which is used to burn plant fumes only when the main incinerator is out of operation. The fume incinerator is fired with fuel oil.

None of the processes listed above have the potential for metals emissions. There will be no contribution to the MEI risk from these additional stacks.

To determine the impact from sources off-site, NYDEC Region 3 was contacted. In the discussions with the NYDEC, it was determined that there are no major sources within a ten kilometer radius of the NEPERA facility.[5] Therefore, it was concluded that there are no additional toxic impacts in the area of the NEPERA stack which need to be addressed in the modeling.

Endnotes

1. Letter dated May 15, 1992 from Mr. Bruce Terbush, NYDEC, to Mr. Sam Martin, NEPERA, Inc., regarding Dispersion Model and Risk Assessment Protocol Comments.

2. Letter dated May 15, 1992 from Mr. Bruce Terbush, NYDEC, to Mr. Sam Martin, NEPERA, Inc., regarding Dispersion Model and Risk Assessment Protocol Comments.

3. Letter dated May 15, 1992 from Mr. Bruce Terbush, NYDEC, to Mr. Sam Martin, NEPERA, Inc., regarding Dispersion Model and Risk Assessment Protocol Comments.

4. Conversation with Alan Elkerton, NYDEC, on June 4, 1992 regarding conversion factors to be used with the Valley Screening Technique.

5. Conversation with Mr. Steve Botsford, NYDEC Region 3, documented in letter to Four Nines, Inc. from Mr. Sam Martin, NEPERA, Inc., dated May 26,1992.

References

Air Guide-1 — Guidelines for the Control of Toxic Ambient Air Contaminants, New York Department of Environmental Conservation, Division of Air Resources, 1991 Edition.

Air Guide-26 — Guidelines on Modeling Procedures for Source Impact Analysis, New York Department of Environmental Conservation, June 27, 1989.

Burning of Hazardous Waste in Boilers and Industrial Furnaces; Final Rule, 40 CFR Part 260, et. al., U.S. Environmental Protection Agency, July 17,1991.

Guidance on Metals and Hydrogen Chloride Controls for Hazardous Waste Incinerators, Volume IV of the Hazardous Waste Incineration Guidance Series, U.S. Environmental Protection Agency, Office of Solid Waste, Document No. EPA/530-SW-90-004, August 1989.

Guidelines on Air Quality Models (Revised), U.S. Environmental Protection Agency, Office of Air and Radiation, Document No. EPA-450/2-78-027R, July 1986.

Guideline for Determination of Good Engineering Practice Stack Height (Technical Support Document for the Stack Height Regulations) (Revised), U.S. Environmental Protection Agency, Office of Air and Radiation, Document No. EPA-450/4-80-023R, June 1985.

Industrial Source Complex (ISC) Dispersion Model User's Guide - Second Edition (Revised) (Abridged), U.S. Environmental Protection Agency, Office of Air and Radiation, Abridgement of Document No. EPA-450/4-88-002a, December 1987.

Regional Workshops on Air Quality Modeling - A Summary Report, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Document No. EPA-450/4-82-015, April 1981.

References

User's Guide For MPTER (Abridged), Thomas E. Pierce and D. Bruce Turner, Environmental Sciences Research Laboratory, Abridgement of Document No. EPA-600/8-80-016, April 1980, and EPA-600/8-86-021, June 1986.

Letter from Alan D. Elkerton, NYDEC, confirming the use of the Stewart/Albany meteorological data, March 25, 1992.

Letter from Mr. Bruce Terbush, NYDEC, to Mr. Sam Martin, NEPERA, Inc., regarding Dispersion Model and Risk Assessment Protocol Comments, dated May 15, 1992.

Letter from Mr. Sam Martin, NEPERA, Inc., to Four Nines, Inc. documenting a conversation with Mr. Steve Botsford, EPA Region II, dated May 26, 1992.

Conversation with Alan Elkerton, NYDEC, concerning conversion factors used with the Valley Screening Technique on June 4, 1992.

Industrial Source Complex Short-Term, Version Dated 92062

COMPLEX I, SCRAM Version Dated 90095

Appendix B: Correspondence Regarding the Air Dispersion Modeling Protocol

The following letter was received from NYSDEC following preliminary discussion of the air dispersion modeling protocol. The SCREEN2 model is mistakenly referenced within the first point of the letter. Instead, the CTSCREEN model is proposed for use in complex terrain regions (consistent with preliminary discussion). Clarification of the intended use of CTSCREEN was confirmed through a phone conversation with Alan Elkerton subsequent to the receipt of the letter.

Cambridge Environmental Inc
58 Charles Street Cambridge, Massachusetts 02141
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New York State Department of Environmental Conservation
1 Wolf Road, Albany, New York 12233

Langdon Marsh
Commissioner

September 12, 1994

Dr. Stephen G. Zemba, Senior Engineer
Cambridge Environmental, Inc.
58 Charles Street
Cambridge, MA 02141

Dear Dr. Zemba:

As discussed at our September 9, 1994 meeting at the Department Central Office, the following is a summary of my comments on the air impact analysis aspects regarding "A Preliminary Health Risk Assessment for the Nepera Incinerator Harriman, New York," prepared by your consulting firm, dated July 27, 1994:

1. It is understood that the EPA ISCST2 and SCREEN2 models will be used for simple terrain and complex terrain impacts, respectively. Intermediate terrain impacts will be determined by the higher concentration produced by either model.

2. To further isolate the magnitude of maximum facility impacts, a 100 meter fine grid receptor analysis will be conducted at locations of maximum facility impacts.

3. Cumulative impacts from other on or off-site hazardous waste incinerator sources, if any, should be addressed.

4. A plant layout diagram showing the location of the source together with the heights of nearby buildings, for determination of Good Engineering Practice (GEP) stack height, should be provided. A direction orientation together with a scale should also be included in addition to the plant property line boundaries.

5. A topographical map centered on the source with a radius of at least 3 km should be provided. Facility property lines should also be included.

6. Determination of urban or rural stability parameters, based on land use, should be addressed as stated in the EPA modeling guidelines.

7. It is not understood why non-metallic organic and inorganic vapor compounds are not considered subject to deposition on emitted pollutant particles and receptors when the opposite is true. It is our position that all pollutants emitted must be modeled in a deposition mode with appropriate deposition velocities.

8. On page 4-7, of the above preliminary health risk assessment, the 0.1-1.0um particle size range together with an assumption of a resultant 0.1 cm\s deposition velocity should be documented.

I hope that my above comments will be helpful in your upcoming revised October 1 trial burn protocol. If I can be of further assistance, please contact me.

Very truly yours,

Alan D. Elkerton

Alan D. Elkerton
Senior Air Quality Policy Analyst
Impact Analysis Section
Bureau of Application Review
and Permitting
Division of Air Resources

cc: L. Sedefian
R. Stanton, Region 3
T. John, Region 3
J. Lauber
G. Pallante
S. Kaminski, DHSR

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Appendix C: Literature on the Sizes of Particles Produced in Combustion Processes

Excerpts from two texts on air pollution are included on the following pages. Both of these references support the assumption that characteristic particle diameters from the Nepera Incinerator will range from 0.1–1.0 μm. Particles of this size form in combustor stack gases due to condensation and accumulation processes.

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Seinfeld (1986), pp. 24-26

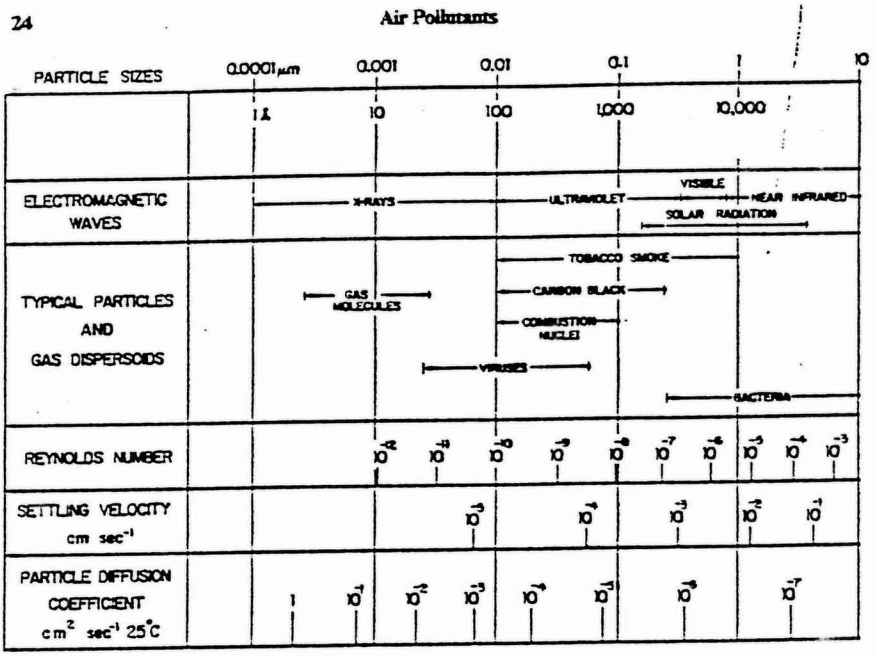

Figure 1.4. Characteristics of atmospheric particles.

The fine and coarse particle modes, in general, originate separately, are transformed separately, are removed from the atmosphere by different mechanisms, require different control techniques, have different chemical composition, and have different optical properties. Therefore, the distinction between fine and coarse particles is a fundamental one in any discussion of the physics, chemistry, measurement, or air quality standards of aerosols. As we will note in Chapter 2, fine and coarse particles differ significantly in their deposition patterns in the respiratory tract.

The phenomena that influence particle sizes are shown in an idealized schematic in Figure 1.5, which depicts the typical distribution of surface area of an atmospheric aerosol. Fine particles can often be divided roughly into two modes: the nuclei mode and the accumulation mode. The nuclei mode, extending from about 0.005 to 0.1 μm diameter, accounts for the preponderance of particles by number; but because of their small size, these particles rarely account for more than a few percent of the total mass of airborne particles. Particles in the nuclei mode are formed from condensation of hot vapors during combustion processes and from the nucleation of atmospheric species to form fresh particles. The accumulation mode, extending from 0.1 to about 1 μm diameter, usually accounts for most of the aerosol surface area and a substantial part of the aerosol mass. The source of particles in the accumulation mode is the coagulation of particles in the nuclei mode and from condensation of vapors onto existing particles, causing them to grow into this size range. The accumulation mode is so named because particle removal

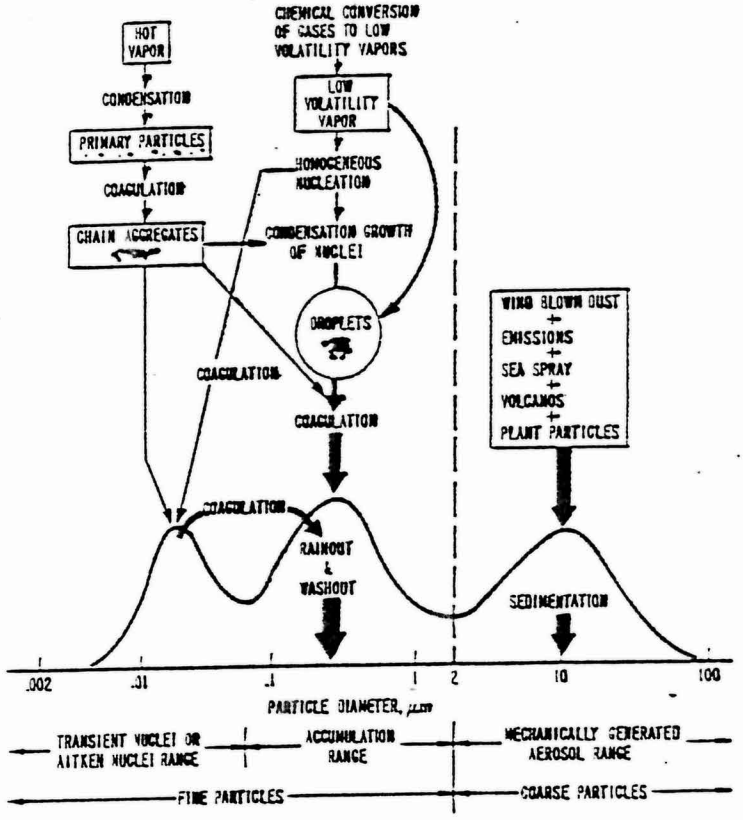

Figure 1.5. Idealized schematic of the distribution of particle surface area of an atmospheric aerosol (Whitby and Cantrell, 1976). The principal modes, sources, and particle formation and removal mechanisms are indicated.

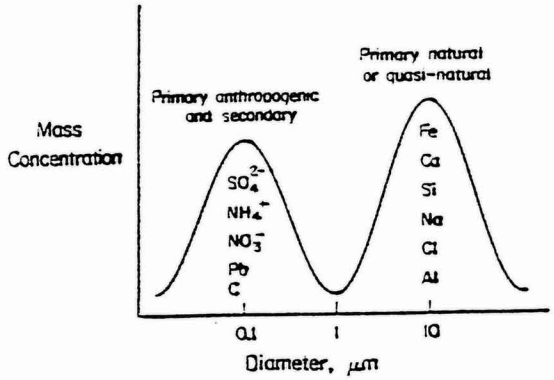

Figure 1.6. Idealized aerosol mass distribution showing a typical segmentation of chemical species into fine and coarse particle fractions.

mechanisms are least efficient in this regime, causing particles to accumulate there. The coarse mode, from 1 to 100 μm diameter, is formed by mechanical processes and usually consists of man-made and natural dust particles.

Whether or not nuclei and accumulation modes are present, the existence of a biomodal distribution with fine and coarse modes has been clearly demonstrated in atmospheric aerosol measurements. Studies in which chemical composition has been determined as a function of particle size also demonstrate the division between fine and coarse modes and show the difference in chemical composition of the two modes. On the basis of such studies, it is possible to divide the major chemical species observed in atmospheric aerosols as shown in Figure 1.6. The major components of the fine fraction of the atmospheric aerosol are sulfate, ammonium, nitrate ions, lead, carbon-containing material including soot and condensed organic matter. In urban areas the fine fraction, as a percent of total suspended particulate matter, varies from 15 to 25% in Denver to 40 to 60% in the Los Angeles and New York–New Jersey urban areas. The percentage of the fine particle fraction that is secondary in nature usually exceeds 50% in these urban areas. Several studies have shown that toxic species, such as polynuclear aromatic compounds, As, Se, Cd, and Zn, are more concentrated in the fine particle fraction. The coarse fraction consists mainly of crustal material, such as Fe, Ca and Si. The major sources are wind erosion products, primary emissions, sea spray, and volcanic eruptions.

1.3.2. Sources of Atmospheric Particulate Matter

Significant natural sources of particles include soil and rock debris (terrestrial dust), volcanic action, sea spray, wild fires, and reactions between natural

TABLE 1.9. Global Estimate of Particles of Natural Origin Smaller than 20 μm Diameter Emitted to or Formed in the Atmosphere[a]

Source	Estimated Emissions ($Tg\ yr^{-1}$)
Soil and Rock Debris	50–250
Forest Fires	1–50
Sea Salt	300
Volcanic Debris	25–150
Particles formed from Gaseous Emissions of H_2S, NH_3, NO_x, and HC	345–1100
Total natural particles	721–1850

[a] United Nations (1979).

Wark and Warner (1981), pp. 146-148

Particulate concentration is usually expressed as the total mass of the particles in a given volume of gas. The basic units for particle concentration are micrograms per cubic meter, although units of grains per cubic foot are well established in the older literature (7000 gr = 1 lb). For conversion or comparison purposes, note that

$$1.0\ \text{gr/ft}^3 = 2.29\ \text{g/m}^3 = 2.29 \times 10^6\ \mu\text{g/m}^3$$

Over the middle of the ocean the atmospheric dust loading is usually much less than 1 $\mu g/m^3$, while in a severe dust storm it may reach 10^9 $\mu g/m^3$. The dust loading in industrial gases typically varies from 10^4 to 10^8 $\mu g/m^3$ (0.01 to 100 gr/ft^3).

5-2 DISTRIBUTION AND SOURCES OF PARTICULAR MATTER

Data are available for the average particle concentration obtained by sampling the atmosphere in cities throughout the world as well as the United States. Table 5-2 is one example of such information [1]. Of the 401 cities sampled, 75 percent at that time had an average particle concentration greater that 80 $\mu g/m^3$. Yet the primary federal air quality standard for suspended particulate is set at 75 $\mu g/m^3$, based on the annual geometric mean. The data of this table show a positive correlation between particulate concentration and city size.

In addition to the average particle concentration in mass per unit volume, it is important to note the size distribution by particle count and by volume in the urban atmosphere. Such distributions for a typical atmospheric particulate sample are shown in Table 5-3. From data in the last two entries, we see that the particles in the 0- to 1-μm range constitute only 3 percent by mass (or volume). However, the number of particles in that range is overwhelming compared with the rest of the sample. Particles of this size range are capable of entering the lungs. From a health standpoint, it is not so much a question of lowering the overall atmospheric dust loading in an urban area, but of decreasing the heavy particulate count in the smaller size range.

In general, particles in the atmosphere in the size range below 1 μm are produced by condensation, while larger particles result from either comminution (pulverization) or combustion. Dry grinding processes are rarely efficient in producing particles smaller than a few microns. Combustion may produce four distinct types of particles. They are formed in the following ways:

1. Heat may vaporize materials which subsequently condense, yielding particles between 0.1 and 1 μm.
2. The chemical reactions of the combustion process may produce short-lived particles of unstable molecular clusters below about 0.1 μm.

TABLE 5-2 DISTRIBUTION OF SELECTED CITIES BY POPULATION CLASS AND PARTICLE CONCENTRATION, 1957–1967

POPULATION CLASS	AVERAGE PARTICLE CONCENTRATION ($\mu g/m^3$)										
	< 40	40–59	60–79	80–99	100–119	120–139	140–159	160–179	180–199	> 200	TOTAL
3 MILLION							1		1		2
1–3 MILLION							2	1			3
0.7–1 MILLION			1		2		4				7
400,000–700,000				4	5	6	1	1	1		18
100,000–400,000		3	7	30	24	17	12	3	2	1	99
50,000–100,000		2	20	28	16	12	6	5	1	3	93
25,000–50,000		5	24	12	12	10	2	1	2	3	71
10,000–25,000		7	18	19	9	5	2	3	1		64
10,000	1	5	7	15	11	2	1	2			44
TOTAL URBAN	1	22	77	108	79	52	31	16	8	7	401

SOURCE: NAPCA. *Air Quality Criteria for Particulate Matter*, AP-49. Washington, D.C.: HEW, 1969.

Table 5-3 PARTICLE DISTRIBUTION BY COUNT AND VOLUME PERCENT OF A TYPICAL ATMOSPHERIC SAMPLE AS A FUNCTION OF SIZE

SIZE RANGE (μm)	AVERAGE SIZE (μm)	PARTICLE COUNT[a]	VOLUME PERCENT[b]
10–30	20	1	27
5–10	7.5	112	53
3–5	4	167	12
1–3	2	555	5
$\frac{1}{2}$–1	0.75	4,215	2
0–$\frac{1}{2}$	0.25	56,900	.1

[a] Count of other sizes relative to count of 20-μm size.
[b] Also mass percent if uniform specific gravity.

3. Mechanical processes may release ash or fuel particles 1 μm or larger.
4. If liquid fuel sprays are involved, a very fine ash may escape directly.
5. Partial combustion of fossil fuels may produce soot.

The stationary sources of particulate emissions may be divided into classes such as household and commercial, industrial, and power. Of the total particulate formed, roughly 85 to 90 percent come from power production sources [5], and the vast majority from power sources is due to the burning of bituminous and lignite coal. Fortunately, with the operation of electrostatic precipitators and other control devices, well over 90 percent of these potential emissions are ultimately removed before release to the atmosphere.

The major industrial sources of particulate pollution are presented in Table 5-4. Asphalt batching in the construction industry is another large potential source. And the giant food and feed industry generates particulates through such processes as soil preparation, insecticide spraying, grain milling and drying, and meat and fish processing.

To facilitate the estimation of industrial emission rates, the U.S. government has published several tables of emission factors based on the quantities of goods or materials processed. Table 5-5 is an extract from a much longer list of emission factors [5]. As an example of the specific sources of emission within a given general category, consider motor vehicles as listed in Table 5-5. Particulate matter emitted by gasoline-fueled vehicles consists of carbon, metallic ash, and hydrocarbon aerosols. Metal-based particles result from the combustion of fuels containing lead antiknock compounds. Carbon and unburned hydrocarbons are the result of incomplete combustion. The particulate matter discharged by diesel engines consists primarily of carbon and hydrocarbon aerosols resulting from incomplete combustion under conditions of severe engine loading. Both the spark-ignition and diesel engines will be treated in greater detail in Chapter 10.

Appendix D: Derivation of Particle Deposition Velocity

The following pages are reproduced from the Preliminary Health Risk Assessment (PHRA) report. These pages describe the derivation of a 0.1 cm/s deposition velocity that is used to estimate rates of particle deposition within the PHRA.

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area in which the air pollution models predict relatively high facility-related impacts. The four lakes/ponds that best satisfied these criteria are listed in Table 4.2.

The modeled air dispersion concentrations at the four lakes/ponds are also listed in Table 4.2. These values are constructed by weighting the modeled impacts of several receptors of the polar coordinate grid that fall within the pond/lake's watershed. Two values are determined for each water body: a concentration over the surface of the water body, and a concentration over lands within the watershed. Table 4.3 lists the modeled concentrations at the specific receptors that are used to construct the average impacts presented in Table 4.2. Average transfer coefficients are calculated by:

$$\alpha_{c,avg} = \frac{\sum_{n} \alpha_c f_c}{\sum_{n} f_c} \qquad (4.2)$$

where the terms are:

- $\alpha_{c,avg}$ the weighted-average transfer factor ($\mu g/m^3$ per g/s);
- α_c the air dispersion transfer factor at the individual receptor ($\mu g/m^3$ per g/s), as described in Equation (4.1);
- f_c the weighting factor for an individual receptor; and
- n the number of receptors in the watershed.

4.1.3 Pollutant-specific concentrations in air and rates of deposition

The modeled air pollutant concentrations in Section 4.1.2 are generated with a nominal emission rate of 1 g/s. Estimates of specific pollutant concentrations in air at the point of maximum impact, as predicted by Equation (4.1) using individual pollutant emission rates (Table 4.4) and the α_c values discussed in Section 4.1.2, are presented in Table 4.5.

Pollutants are likely to be emitted from the NEPERA incinerator in both vapor and particle-bound phases. The relative volatilities of the chemicals of concern suggest the consideration of two broad categories. Volatile compounds, such as the organic waste stream constituents and inorganic compounds such as ammonia and possibly some metals, are likely to be released as vapors. Metallic compounds such as nickel, chromium, and lead, however, may condense onto or within solid particles.

For this assessment we treat organic compounds and non-metallic inorganic compounds as vapors, and metallic compounds as particle-bound pollutants. The significance of this

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generalization pertains to the assumed treatment of atmospheric deposition. Specifically, the following assumptions are made:

- chemicals emitted as vapors are assumed not to deposit to an appreciable extent within the study domain;[5] and

- metallic compounds released from the stack are assumed to deposit at ground-level to water, soil, and vegetation as components of small particles.[6]

The deposition rate D_p (mass per unit area per unit time) is estimated as:

$$D_p = c_a v_d \tag{4.3}$$

where v_d is a deposition, or settling, velocity of the airborne particles. Deposition velocities, which can differ among chemical species, are typically determined using procedures published by the California Air Resources Board (CARB) or other sources for the assessment of deposition rates of aerosol emissions from stationary sources. In the CARB procedure, Equation (4.3) may be applied on an hourly basis, and the deposition velocity estimated from local meteorological conditions (wind speed, atmospheric stability, and temperature), local terrain, and particle characteristics (density and size distribution). Hourly depositions are summed for each year of the multi-year modeling period to obtain average estimates of annual deposition rates of contaminants that may be emitted from the incinerator stack. Since the air concentration (c_a) is proportional to emission rate (E), time-averaged annual particle deposition rates D_{pt} may be expressed as the product of the contaminant emission rate (E) and a normalized deposition parameter β_d:

$$D_{pt} = E\beta_d \tag{4.4}$$

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[5] The tendency for these pollutants not to bioaccumulate in environmental media is further justification for assuming insignificant deposition.

[6] Small particles are expected during typical operation because metals are not used in NEPERA production processes and not intentionally burned in the incinerator — the large residual particles that could be expected from the burning of metal-bearing wastes are likely to be absent from the flue gas. Hence, metals from the flue gas are expected to create or condense onto small particles. In previous stack testing of the facility, the fact that particle loadings were difficult to collect in significant quantities supports this assumption (based on conversation with Martin, 1994).

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In addition to meteorological parameters, the normalized deposition rate (β_d) of a particle-bound contaminant depends on particle properties. Figure 4.5 depicts deposition velocities v_d estimated with the CARB procedures for various particle sizes and atmospheric roughness heights. Four curves correspond to roughness heights ranging from 5 cm to 100 cm, which are characteristic of land use ranging from relatively smooth surfaces such as water to well-vegetated areas such as forests. Values at each point are calculated by weighting deposition velocities over the spectrum of wind speeds and stability classes present within the meteorological data collected at Stewart Air Force Base.

Assuming the NEPERA facility emits particles in the 0.1–1.0 μm size range, deposition velocities can be expected to be less than 0.1 cm/s. As a simplification, a single deposition velocity v_d of 0.1 cm/s is assumed to estimate deposition rates[7]. The normalized deposition rates at the location of maximum impact and within the four watershed areas are provided in Table 4.6. Table 4.7 lists the compound-specific deposition rates predicted by Equation (4.4) for the maximum impact point and the two watershed areas (Cranberry Lake and Swimming Pond) used to assess exposure.[8]

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[7] Particulate-bound compounds emitted by the NEPERA facility may either be adsorbed to the surface of a particle or entrained in the particle. Surface-weighted and mass-weighted deposition velocities are usually used for each of these cases, respectively. However, since the particle size distribution in the stack gas is unknown, surface-weighted and mass-weighted deposition velocities cannot be calculated with precision.

[8] As explained in Section 2.2, only two of the four lakes and ponds evaluated enter into the quantitative risk assessment. These are Cranberry Lake and Swimming Pond. Although the deposition rates to the other waterbodies evaluated are higher than those to Cranberry Lake and Swimming Pond, the surface water modeling (described in Section 4.3) predicts higher overall impacts to Cranberry Lake and Swimming Pond as a result of differences in other modeling parameters such as soil runoff and surface area of the waterbody. The parameters listed in Table 4.6 and elsewhere allow for the calculation of surface water concentrations in the other two lakes.

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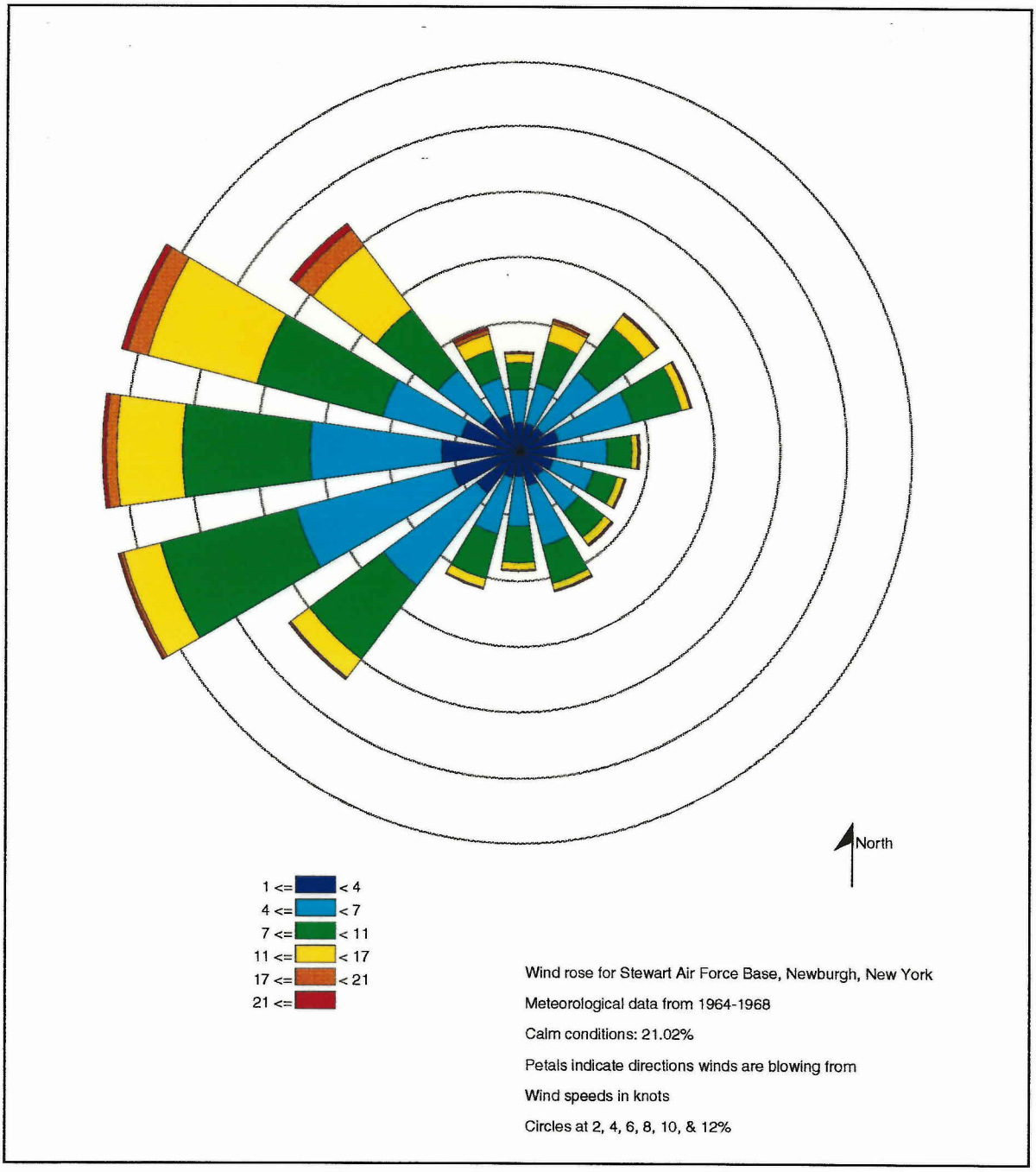

Figure 4.1 Wind rose of meteorological data collected at the Stewart Air Force Base, Newburgh, New York, from 1964–1969. Petals indicate the direction from which winds originate, and the length of each petal indicates the frequency of occurrence. The colors of each petal reflect different wind speed categories.

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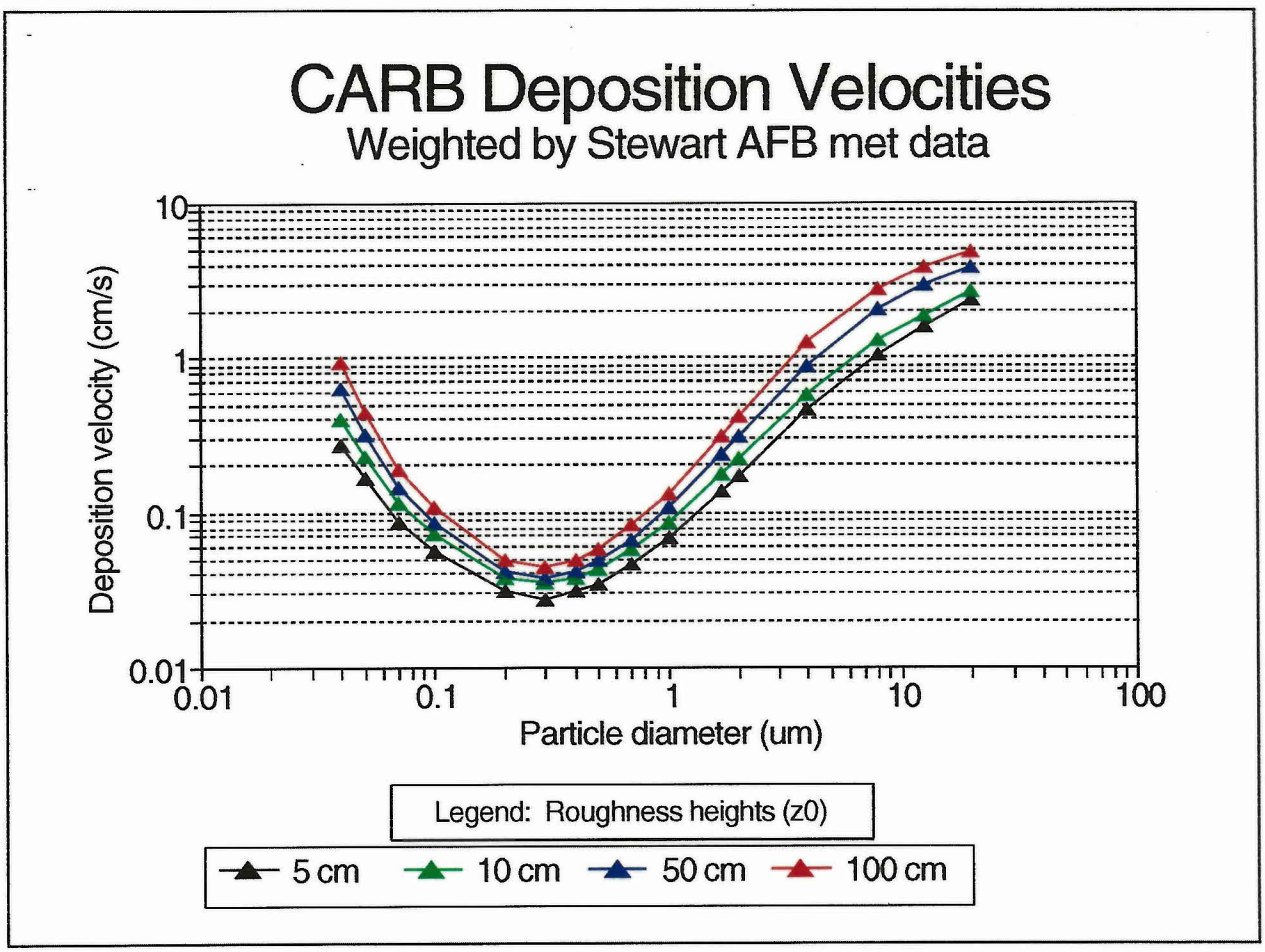

Figure 4.5 Particle deposition velocities estimated with CARB procedures. Curves correspond to differing roughness heights (z_0). Deposition velocities reflect the distribution of meteorological observations collected at the Stewart Air Force Base.

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